ASSIGNMENT 4

The learning goal of this assignment is to be able to construct, analyze, and understand Bode diagrams.

The circuit schematic in the appendix shows some sort of linear feedback system. If you look closely at the operational amplifiers and their functions, you will find that A1 is an addition/subtraction stage which adds the input and the output of A3 (both with negative sign) to the feedback signal coming from A2 through potentiometer R7. Both A2 and A3 are configured as inverting integrators with the transfer function $H_{INT}(s) = -a/s$ where $a=(R4 \cdot C1)^{-1}$. For another hint, use $C(s)=3\,k\,B(s) - A(s) - X(s)$ as the equation of the first summation point and the first op-amp with A(s), B(s), C(s) the three outputs and X(s) the input.

STEP 1: ANALYSIS OF THE SYSTEM

Task 1: Draw a block diagram of the feedback system with blocks for all amplifiers (and attenuators, such as R6/R7), integrators, and addition stages. Use the symbols $\tau = R4 \cdot C1 = R5 \cdot C2$ and a value of K*R6/R7 ($0 \le K \le 1$) for the voltage divider R6/R7 where K represents the potentiometer position.

Task 2: Compute the transfer functions for all three outputs, i.e.,

$$H_1 = \frac{\text{Output } A}{\text{Input}} \; ; \quad H_2 = \frac{\text{Output } B}{\text{Input}} \; ; \quad H_3 = \frac{\text{Output } C}{\text{Input}}$$

Task 3: Create a simulation in Scicos. Plot the step responses of all three outputs. Important Scicos note: When you use R4=R5=100k and C1=C2=1.5nF, your characteristic frequency is around 1 kHz. Scicos cannot resolve 1 kHz in its default setting. For this reason, use $\tau=1$ in your simulation. The Bode diagrams of your simulated system and the real system in the next task are shifted accordingly.

STEP 2: REALIZATION AND FREQUENCY ANALYSIS OF THE SYSTEM

Task 4: Build the circuit. If you have any doubt whether the your circuit is working, try to compare it to your Scicos simulation. Look at the step response, then apply a slow-frequency square wave to your circuit's input and check if they match. A good choice for C1 and C2 is 1.5nF.

Task 5: Measure the frequency response and draw the Bode diagrams for all three outputs. Use $f = (2\pi\tau)^{-1}$ as your central frequency. Start at about f/100 and increment logarithmically (for example: 10 Hz, 20 Hz, 50 Hz, 100Hz, 200 Hz...) to about 100f. Keep your potentiometer R7 at its lowest position (wiper to ground), so that K=0.

Task 6: Using the poles and zeroes from the transfer functions you determined in Task 2, add the asymptotes to your diagram. If your frequency response and your asymptotes don't match, you need to trouble-shoot Tasks 4-6 until they match.

Task 7: Determine the frequency response of the system for two more positions of potentiometer R6, one with the wiper in the central position (K close to 0.5) and one at the high end (K close to 0.9, the maximum). You only need to cover the range f/10 to 10f.

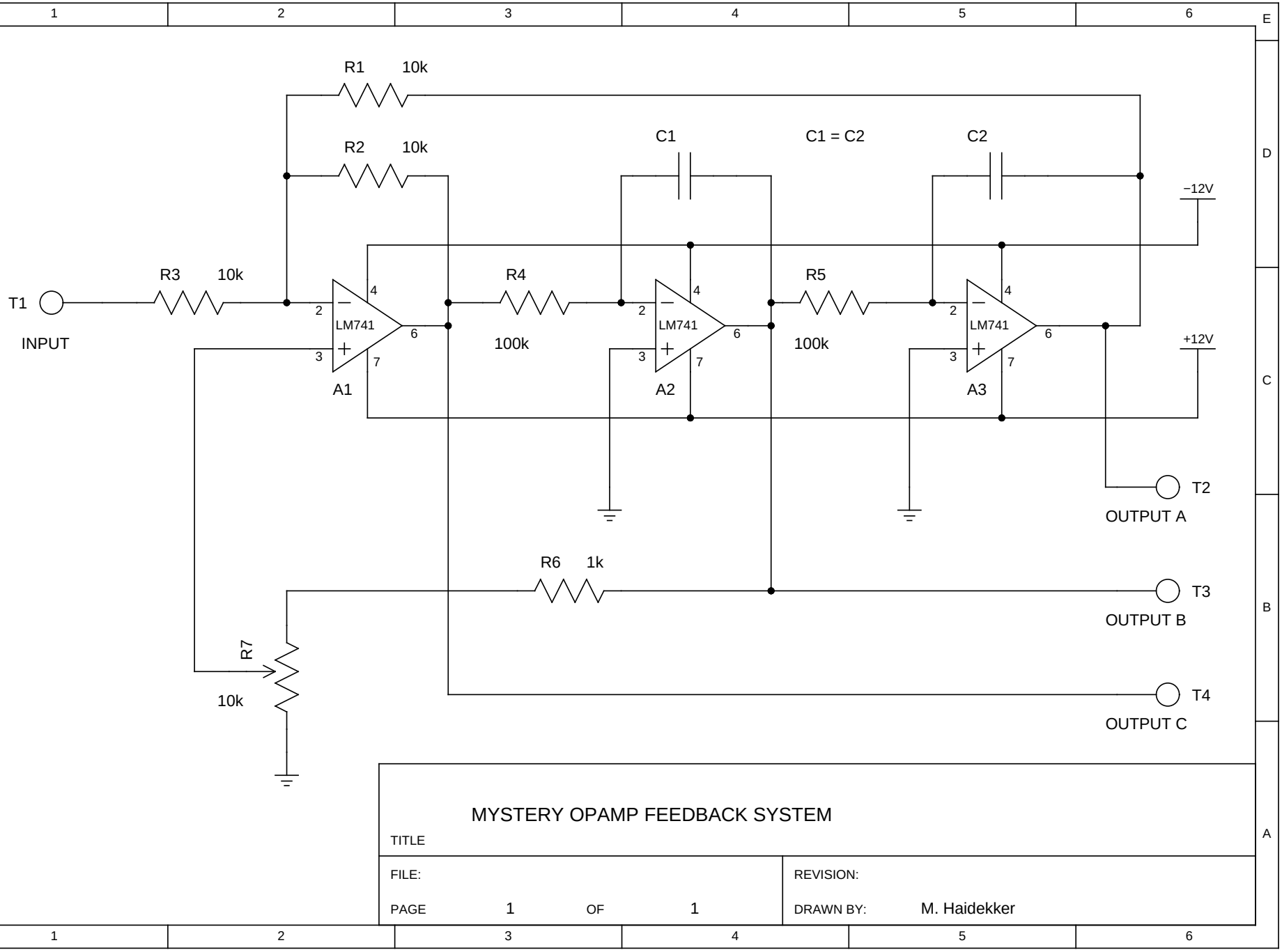
TURN-IN:

This assignment is split into two parts. The first part is supposed to be solved by each student individually. The second part is intended to be solved in teamwork. You are required to turn in two typewritten reports (Step 1 and Step 2) at the respective assigned due dates. The reports should contain all plots, equations, derivations, and descriptions of the procedures. For the second part, each team may turn in a joint report. The usual reporting rules (see Assignment 1) apply.

Score points will be assigned as follows:

STEP 1 (individual turnin):
Task1 (5), Task 2 (10), Task 3 (5)
STEP 2 (team turnin):
Task 4 (10), Task 5(10), Task 6(5), Task 7 (5)

TURNIN: Legible, understandable, well-organized, timely report (2x5)
for a total maximum score of 60 points.


R1 10k
R2 10k
C1
C1 = C2
C2
−12V
+12V
R3 10k
R4
R5
T1
INPUT
LM741
A1
A2
A3
100k
100k
T2
OUTPUT A
R6 1k
T3
OUTPUT B
R7
10k
T4
OUTPUT C
MYSTERY OPAMP FEEDBACK SYSTEM
TITLE
FILE:
REVISION:
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